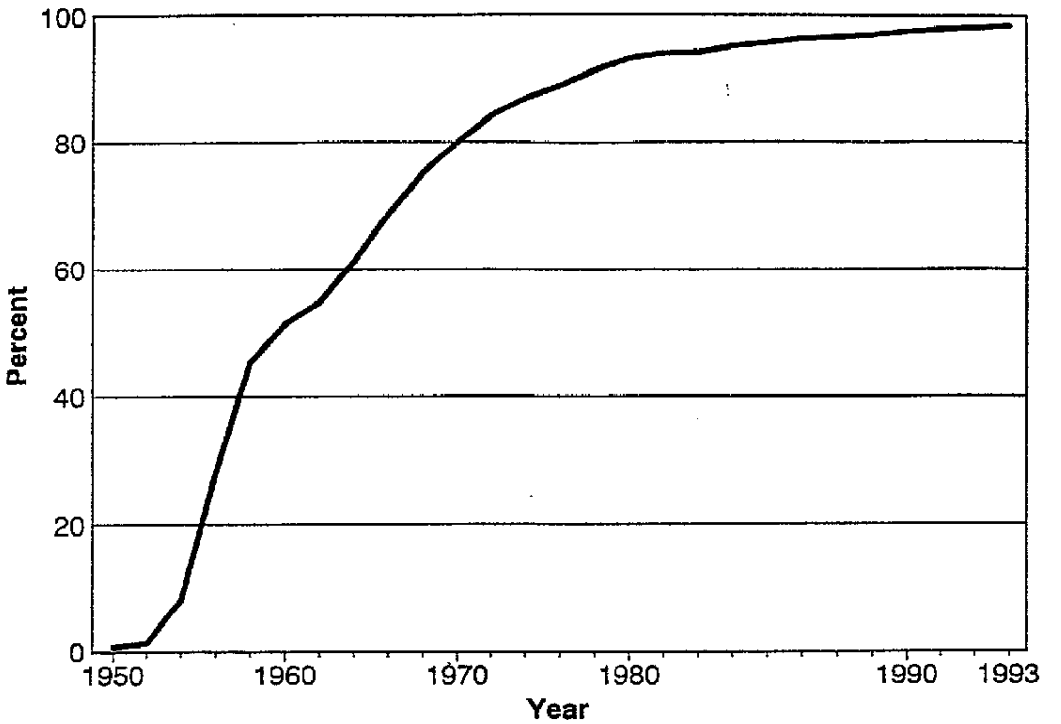
SMOKING AND TOBACCO CONTROL

MONOGRAPH 7

The FTC Cigarette Test Method for Determining Tar, Nicotine, and Carbon Monoxide Yields of U.S. Cigarettes

Report of the NCI Expert Committee

Figure 2
Percentage of all U.S. cigarettes with filter tips



Source: U.S. Department of Agriculture, 1994.

inner core of the burning cone is depleted of oxygen, and thus the levels of carbon monoxide, hydrogen cyanide, and some other volatiles are selectively reduced in the smoke of cigarettes with perforated filter tips (Figure 3) (National Cancer Institute, 1977). Furthermore, the lower velocity of the generated smoke increases the efficiency of the filter. However, the tumorigenicity of the resulting tar does not change compared with that of the tar of a conventional, nonperforated cellulose acetate filter cigarette (National Cancer Institute, 1977). In principle, the smoke of a cigarette can be diluted to an unlimited degree by air; however, the consumers' nonacceptance of these cigarettes is the limiting factor.

The use of charcoal particles in one of two or three sections of a filter tip, or sprayed onto the cellulose acetate, also offers the opportunity to selectively reduce certain volatile smoke constituents, such as the ciliatoxic hydrogen cyanide, acetaldehyde, and acrolein (National Cancer Institute, 1977; Tiggelbeck, 1968). However, replacing one section of the filter tip with charcoal also leads to less reduction of TPM than can be achieved with

hazardous cigarette. The results documented that RT, especially RT resulting from the paper process with cellulose fiber as an additive, offered an opportunity to significantly reduce the cigarette smoke yields of tar, nicotine, phenols, and PAHs, as well as the tumorigenicity of the resulting tar. The most encouraging results were achieved with RT resulting from the paper process using only tobacco stems (Table 2).

Today, most blended U.S. cigarettes contain 20 to 30 percent RT, which is also now widely used in Europe, Canada, and Japan.

Puffed, Expanded, and Freeze-Dried Tobaccos

In the early 1970's a new tobacco preparation was introduced for the blended cigarette, that of "puffed," "expanded," or "freeze-dried" tobacco. Using these materials, less tobacco is required to fill a cigarette. The principle is to expand the tobacco cell walls by quick evaporation of water and other vaporizable agents. This causes a rapid pressure increase in the cells by heat and/or the reduction of external pressure.

Table 3 summarizes the smoke yields of experimental cigarettes made exclusively from puffed, expanded, or freeze-dried tobaccos. The smoke data are compared with those from the smoke of the control cigarette. The tars from the smoke of cigarettes made from expanded and freeze-dried tobaccos were significantly less tumorigenic than tar from the control cigarettes (National Cancer Institute, 1980).

Table 2
Smoke yields of cigarettes made from reconstituted tobacco (RT) by paper processes and from control cigarettes

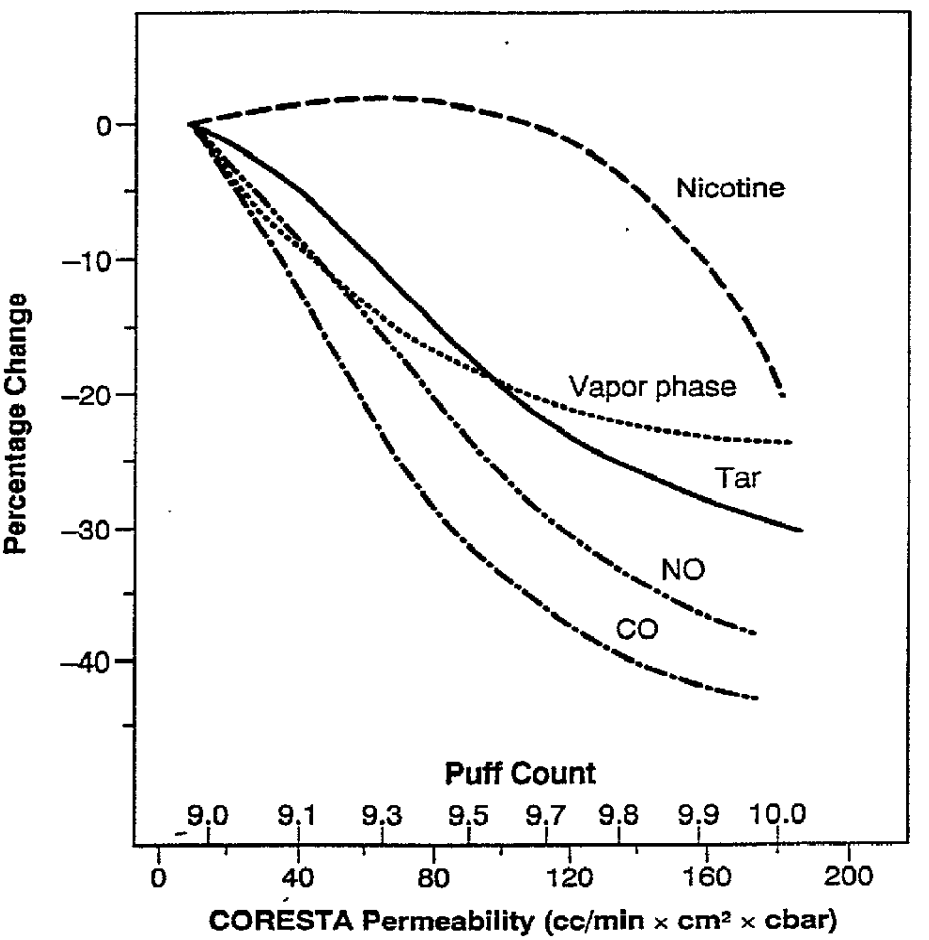
Components	RT Stems Only	RT Blend	Control
Weight (mg)	1,011.0	1,060.0	1,226.0
Tar (mg)	11.3	11.7	25.9
Nicotine (mg)	0.2	0.7	1.7
Carbon Monoxide (mg)	11.9	11.8	16.1
NO_x (µg)	586.0	343.0	367.0
Hydrocyanic acid (µg)	73.5	81.9	201.0
Acetaldehyde (µg)	1,027.0	948.0	1,065.0
Acrolein (µg)	99.0	105.0	109.0
Benz(*a*)anthracene (ng)	13.1	9.8	46.3
Benzo(*a*)pyrene (ng)	8.9	7.4	27.8

Key: NO_x = N (>95 percent) + NO_2 (<5 percent).

Source: National Cancer Institute, 1976a and 1976b.

Cigarette Paper With increasing permeability, porous cigarette papers significantly reduce tar, carbon monoxide, and nitrogen oxides but not low-molecular-weight gas phase components in the smokestream. Perforated cigarette paper also significantly reduces hydrogen cyanide, whereas nicotine reduction is less (National Cancer Institute, 1977) (Figure 5). In a recent study it was found that porous cigarette paper reduces not only smoke yields of carbon monoxide and tar but also of volatile nitrosamines, TSNAs, and benzo(*a*)pyrene (BaP) (Brunnemann et al., 1994). However, the reduction

Figure 5
Percentage change in smoke yield and composition with perforated, 0.5 percent citrate paper



Key: NO = nitrogen oxide; CO = carbon monoxide.

Source: Owens, 1978.

Table 3
Smoke analysis of cigarettes made from puffed, expanded, and freeze-dried tobaccos and from control cigarettes

Smoke Component	Puffed Tobacco	Expanded Tobacco	Freeze-Dried Tobacco	Control
Carbon Monoxide (mg)	9.33	11.80	12.30	18.00
Nitrogen Oxides (μg)	247.00	293.00	235.00	269.00
Hydrogen Cyanide (μg)	199.00	287.00	234.00	413.00
Formaldehyde (μg)	20.70	21.70	33.40	31.70
Acetaldehyde (μg)	814.00	720.00	968.00	986.00
Acrolein (μg)	105.00	87.70	92.40	128.00
Tar (mg)	15.60	18.20	16.30	36.70
Nicotine (mg)	0.78	0.74	0.82	2.61
Benz(*a*)anthracene (ng)	13.70	11.80	15.30	37.10
Benzo(*a*)pyrene (ng)	11.80	8.20	9.20	28.70

Source: National Cancer Institute, 1976b.

The use of puffed, expanded, or freeze-dried tobacco, together with the use of filter tips and reconstituted tobaccos, has had a major impact on the amounts of leaf tobacco needed per average U.S. cigarette. In about 1950 1,230 mg of leaf tobacco were required for one cigarette, whereas only 785 mg were needed in 1982 (Grise, 1984).

Physical Parameters of Cigarettes

As the length of a cigarette increases, there is more opportunity for air to enter through the paper and for certain gaseous components, for example, carbon monoxide and hydrogen cyanide, to diffuse out of the paper into the environment. Assuming that all other factors remain the same and only the length of the cigarette increases, there will be a higher smoke yield of tar and nicotine because more tobacco is burned (Moore and Bock, 1968). In the past, it was claimed that tobacco absorbs only slightly less of the smoke particulates than a cellulose acetate filter tip (Dobrowsky, 1960). This may have been true in the early 1960's, but modern cellulose acetate filter tips are more efficient in retaining smoke particulates than the tobacco column of a cigarette.

Length

Circumference

With the packing density remaining constant, a decrease in circumference of a cigarette reduces the amount of tobacco available for burning. As a result, tar and nicotine yields in the smokestream are reduced (Table 4) as are the yields of carbon monoxide and several other volatile smoke constituents (DeBardeleben et al., 1978).

CONCLUSIONS *The Health Consequences of Smoking: The Changing Cigarette: A Report of the Surgeon General* (U.S. Department of Health and Human Services, 1981) offered conclusions on these three major classes of disease. Do these conclusions remain tenable in light of more recent evidence?

With regard to cancer, the report concluded that:

> Today's filter-tipped, lower 'tar' and nicotine cigarettes produce lower rates of lung cancer than do their higher 'tar' and nicotine predecessors. Nonetheless, smokers of lower 'tar' and nicotine cigarettes have much higher lung cancer incidence and mortality than do nonsmokers (U.S. Department of Health and Human Services, 1981, p. 18).

The more recent case-control evidence remains consistent with the first component of this conclusion.

With regard to COPD, the report concluded that it was unknown whether risk was lower for smokers of low-tar and -nicotine cigarettes